

## **NRL Satellite Support for DYNAMO Field Program**

Jeffrey D. Hawkins  
Naval Research Laboratory  
7 Grace Hopper Avenue  
Monterey, CA 93943-5502

Phone: (831)-656-4833 Fax: (831) 656-4769 email: [Jeff.Hawkins@nrlmry.navy.mil](mailto:Jeff.Hawkins@nrlmry.navy.mil)

Document Number: N0001412WX20870

### **LONG-TERM GOALS**

To provide the ONR-sponsored DYNAMO field program with a robust suite of satellite meteorology products capable of tracking mesoscale convective clusters associated with the Madden Julian Oscillation (MJO) in the Indian Ocean.

### **OBJECTIVES**

Develop a NRL-MRY near real-time web page that enables DYNAMO field program participants to view the evolving organization of convective clusters with a suite of geostationary (GEO) and low earth orbiting (LEO) satellite sensors.

### **APPROACH**

GEO visible, infrared (IR), and water vapor (WV) imagery can provide the synoptic and mesoscale views required to monitor the general convective organization and its temporal changes. The Meteosat-7 satellite provides this data set for the DYNAMO project and these products were available every 30 minutes. The web page provided animation or looping capabilities that are needed to view multi-day convection changes and determine if organization is increasing in specific areas that may lead to MJO genesis.

However, the inability to view through expansive upper-level clouds is detrimental to tracking clouds that are actually producing rain, thus LEO microwave imagers were used to create rainrate products. In addition, we used the NRL-MRY “blended” rainrate product that incorporates both GEO and LEO data sets. The more accurate microwave imager data is used to “train” the GEO IR cloud tops as to what rainrate value should be associated with a given cold cloud top temperature. Thus a dynamic histogram look-up table is created for small geographical domains and the look-up table is updated every time a microwave imager overflies. This blending method is used by NOAA and others for a variety of global and regional rainrate products.

Additional microwave imagery products were produced that included ocean surface wind vectors from ASCAT and WindSat, horizontal and vertical polarization 85-91 GHz imagery from SSMI, SSMIS, and AMSR-E/TMI sensors and sea surface temperatures from AMSR-E. The microwave product suite

## Report Documentation Page

*Form Approved  
OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>2012</b>	2. REPORT TYPE <b>N/A</b>	3. DATES COVERED <b>-</b>		
4. TITLE AND SUBTITLE <b>NRL Satellite Support for DYNAMO Field Program</b>		5a. CONTRACT NUMBER		
		5b. GRANT NUMBER		
		5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S)		5d. PROJECT NUMBER		
		5e. TASK NUMBER		
		5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Naval Research Laboratory 7 Grace Hopper Avenue Monterey, CA 93943-5502</b>		8. PERFORMING ORGANIZATION REPORT NUMBER		
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S)		
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>				
13. SUPPLEMENTARY NOTES <b>The original document contains color images.</b>				
14. ABSTRACT				
15. SUBJECT TERMS				
16. SECURITY CLASSIFICATION OF:		17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>5</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>			

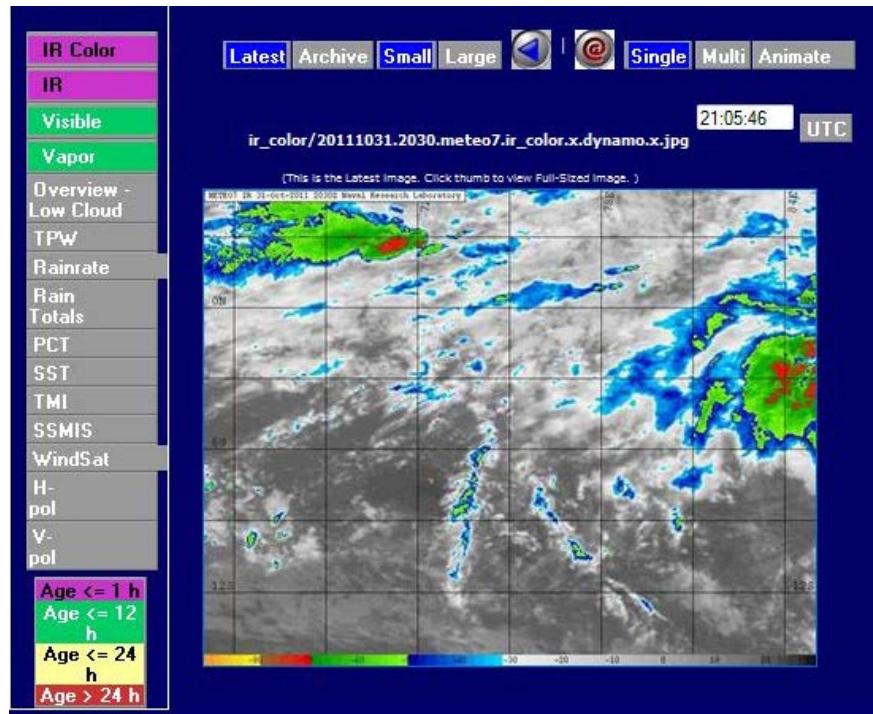
also included total precipitable water (TPW) and polarization corrected temperatures (PCT) that help the user located rain clouds.

## WORK COMPLETED

1. Created NRL-MRY web page with a suite of multi-spectral satellite meteorology products geared toward real-time support of the ONR DYNAMO field program in the Indian Ocean from October 2011 to March 2012.
2. NRL-MRY web page product suite included the following satellite products:
  - Met-7 visible, infrared, and water vapor imagery focused on field program domain,
  - Rainrate products created by blending GEO IR and microwave imager data,
  - Horizontal and vertical polarization ice scattering channel microwave imager data,
  - Polarization corrected microwave imager data sets,
  - Ocean surface wind vectors from ASCAT and WindSat
  - Sea surface temperature (SST) products using AMSR-E
  - Low cloud at night products using multi-channel IR data
3. NRL-MRY web products are available on-line for the entire multi-month project for use by the DYNAMO scientific community.

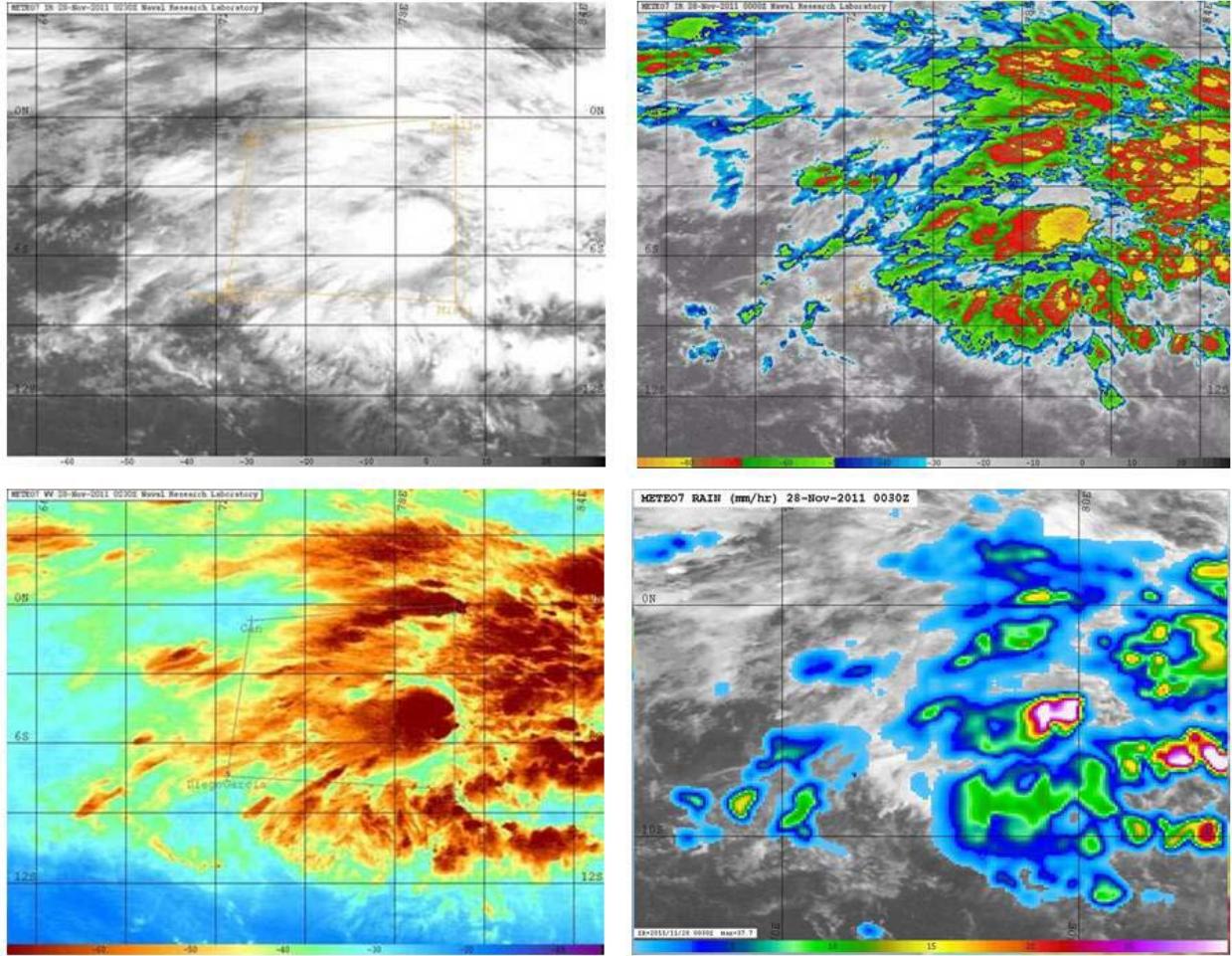
## TECHNICAL RESULTS

### Section 1: DYNAMO Field Program



**Figure 1. NRL-MRY DYNAMO satellite meteorology product web page available to field program participants in near real-time for the specific Indian Ocean domain.**

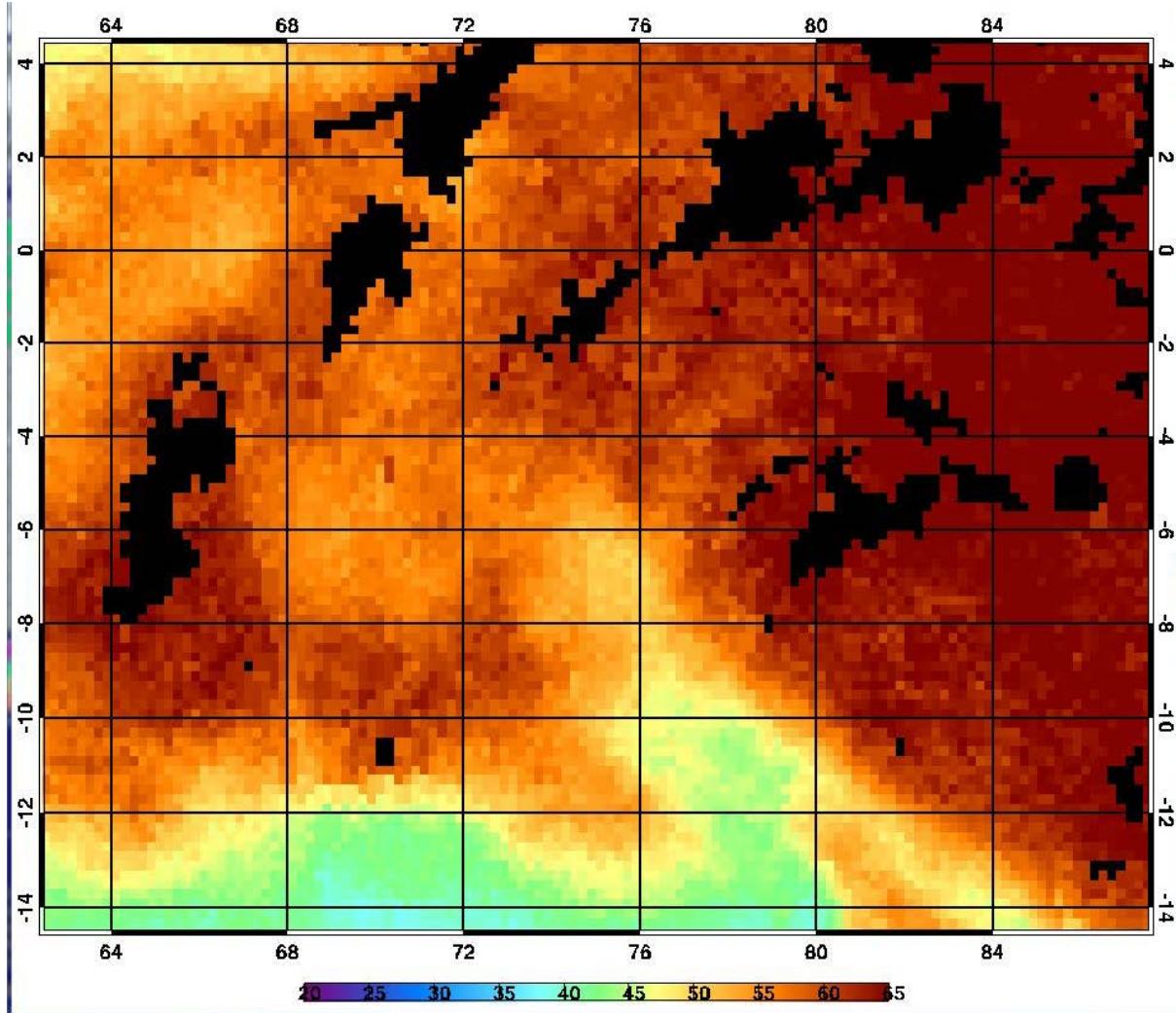
The DYNAMO field program needed a multi-satellite suite of products in order to ascertain the mesoscale and synoptic scale convection associated with the Madden Julian Oscillation (MJO) cycle. The project was interested in capturing MJO onset and in order to accomplish this task needed to view a large domain with visible (vis), infrared (IR), and water vapor (WV) sensors as well as microwave imagers that permit accurate rain retrievals. A sample set of vis, IR, WV and rainrate imagery is highlighted in Fig. 2 below for November 28, 2011 for the DYNAMO field program domain.



**Figure 2. NRL-MRY DYNAMO satellite meteorology products on Nov. 28, 2011 including a) upper-left, regular IR enhancement, b) upper-right, false color IR to highlight cold cloud tops, c) lower-left, water vapor imagery showing upper-level moisture patterns, and d) NRL-MRY blended rainrates for the same timeframe (lat/lon lines are different, but the scale are nearly identical).**

Note that the user is able to correlate the coldest cloud tops with the higher rainrates that are verified in part by the microwave imager data sets. Also, thin cirrus clouds do not produce rain and this is in agreement with the rainrate product in the lower right of Fig. 2. The blended rainrate product updates with the 30 minute frequency of the Meteosat-7 GEO data, thus users are afforded with rapid temporal sampling while leaning on the microwave data, since there is not a one to one correlation between cloud top temperatures and rainrate. The blended rainrates could be animated to visualize the organization of mesoscale convective rain events.

Understanding the 3-D moisture environment is crucial to the DYNAMO team members, thus total precipitable water (TPW) was calculated using microwave imager near real-time data sets. Figure 3 is an example for Nov. 28, 2011 at 0000Z. As expected, the majorities of the domain is moisture laden, but note the sharp boundary near the southern edge of the field program domain. The moisture pattern changed significantly along this edge during the course of the multi-month field mission.



**Figure 3. NRL-MRY DYNAMO total precipitable water (TPW) product for Nov. 28, 2011 using microwave imager digital data sets.**

Field program scientists used the products by overlaying potential NOAA P-3 flight tracks as they attempted to map the relevant mesoscale rain feature development with airborne radar to supplement the island-based radar data sets. The digital data for the NRL-MRY DYNAMO web page have been retained at NRL and are available for the scientific community to delve into deeper during post analysis.

## **IMPACT/APPLICATIONS**

The suite of GEO/LEO multi-spectral satellite meteorological products will enable the DYNAMO science team to better comprehend the 3-D environment that evolved over the multi-month field program by offering both high temporal resolution (GEO) and all-weather (microwave imager) products geared toward monitoring mesoscale convection at spatial resolutions that match Madden-Julian oscillation scales.

## **TRANSITIONS**

The NRL-MRY Dynamo satellite products created in near real-time have been archived and are available for all users for retrospective scientific studies.

## **RELATED PROJECTS**

This project is closely related to a 6.4 effort sponsored by the Program Executive Office for C4I&Space/PMW-120 entitled “Satellite METOC” funded under PE 0603207N. The 6.4 project serves as the transition vehicle, works closely with the Fleet Numerical Meteorology and Oceanography Center (FNMOC, Monterey, CA). The project also benefits from the NOAA/JPSS funded NexSat project ([www.nrlmry.navy.mil/NEXSAT.html](http://www.nrlmry.navy.mil/NEXSAT.html)) that provides a suite of satellite meteorology products in near real-time to Internet users worldwide.

## **REFERENCES**

Hawkins, J. D. and C. Velden, 2011, Supporting meteorological field experiment missions and post-mission analysis with satellite digital data and products, *Bull. Amer. Meteor. Soc.*, 92, 1009-1022.

## **PUBLICATIONS/Presentations**

Hawkins, J., K. Richardson, and J. Kent, 2012, NRL Remote Sensing DYNAMO Overview, DYNAMO Science Team Meeting.